

## Understanding the Reactivity of Lunar Dust for Future Lunar Missions

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During the Apollo missions, dust was found to cause numerous problems for various instruments and systems. Additionally, the dust may have caused momentary health issues for some of the astronauts. Therefore, the plan to resume robotic and manned missions to the Moon in the next decade has led to a renewed interest in the properties of lunar dust, ranging from geological to chemical to toxicological. An important property to understand is the reactivity of the dust particles. Due to the lack of an atmosphere on the Moon, there is nothing to protect the lunar soil from ultraviolet radiation, solar wind, and meteorite impacts. These processes could all serve to “activate” the soil, or produce reactive surface species. On the Moon, these species can be maintained for millennia without oxygen or water vapor present to satisfy the broken bonds. Unfortunately, the Apollo dust samples that were returned to Earth were inadvertently exposed to the atmosphere, causing them to lose their reactive characteristics.

In order to aid in the preparation of mitigation techniques prior to returning to the Moon, we measured the ability of lunar dust, lunar dust simulant, and quartz samples to produce hydroxyl radicals in solution[1]. As a first approximation of meteorite impacts on the lunar surface, we ground samples using a mortar and pestle. Our initial studies showed that all three test materials (lunar dust (62241), lunar dust simulant (JSC-1Avf), and quartz) produced hydroxyl radicals after grinding and mixing with water. However, the radical production of the ground lunar dust was approximately 10-fold and 3-fold greater than quartz and JSC-1Avf, respectively. These reactivity differences between the different samples did not correlate with differences in specific surface area. The increased reactivity produced for the quartz by grinding was attributed to the presence of silicon- or oxygen-based radicals on the surface, as had been seen previously[2]. These radicals may also play a part in the reactivity of the lunar dust and lunar simulant. However, other factors would seem to be required to account for the greatly increased reactivity of the lunar soil. It was proposed that nanometer-size  $\text{Fe}^0$  (zero valent) particles in the lunar soil might play a role, as they are not present in quartz or lunar dust simulant.

The present work has been performed with the aim of understanding the origin of the considerable reactivity of lunar dust[3]. We have ground 8 lunar soils of varying maturity and source (highland or mare) and measured the hydroxyl-radical production and decay of the reactivity. It was determined that there is a direct correlation between the reactivity and the amount of nanophase metallic iron particles (as a function of soil maturity,  $I_s/\text{FeO}$ , in which  $I_s$  is the amount of iron present as nanophase iron particles present and FeO is the total iron content) in the samples; thus, the highland soils, with their lesser total FeO content, are less reactive than ground mare soils. Additionally, grinding of nanophase iron simulant [4] showed reactivity in line with the lunar soils and much greater than lunar dust simulant or quartz. Studies aimed at determining the time required to “deactivate” the reactive soils in a habitable environment showed that the average time to reach 50% of the initial reactivity was approximately 3.5 hours. However, even after one week, none of the soils had returned completely to its unground level of reactivity. In contrast to the reactivity results, there was no obvious correlation between the maturity of the soil and its deactivation time. These results provide the first chemical reactivity and persistence values as an important property of lunar soils, data that is paramount as mankind prepares to return to the Moon.

1. W.T. Wallace, et al., Lunar dust and lunar simulant activation and monitoring. *Meteor. Planet. Sci.* **44**(2009) 961-970.
2. V. Castranova, Generation of oxygen radicals and mechanisms of injury prevention. *Environ. Health Perspect.* **102**(1994) 65-68.
3. W.T. Wallace, et al., Nanophase iron-induced chemical reactivity of ground lunar soil. *Earth Planet. Sci. Lett.* (2009) submitted.
4. Y. Liu, et al., Unique properties of lunar impact glass: nanophase metallic Fe synthesis. *Amer. Mineral.* **92**(2007) 1420-1427.